APPROVED	O.G. FIG.	
BY	CLASS	SUBCLASS
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FIG. 1

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FIG. 2

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BEGIN

READ IN OR BUILD
A SYNTHETIC SNAPSHOT — 72

USING THE SYNTHETIC SNAPSHOT,
BUILD A DEFAULT IMAGE
AND STRUCTURAL MODE — 74

USING THE GEOMETRIC DATA
IN THE PACKAGE LIBRARY
TO BUILD A GEOMETRIC MODEL — 76

INPUT A REGION OF INTEREST ON
THE BOARD THAT SHOULD
CONTAIN THE COMPONENT — 78

82 — IS THE PART PRESENT?

NO

YES

MATCH THE IMAGE AND STRUCTURAL
MODELS TO THE REGION OF
INTEREST TO DECIDE
IF THE COMPONENT IS PRESENT — 80

USE THE ROUGH LOCALIZATION IN
THE LAST STEP AS A SEED FOR THE
GEOMETRY MODEL. GEOMETRY
MODEL WILL FIND THE EXACT
BOUNDARIES OF THE COMPONENT — 84

ROTATE THE IMAGE DELINEATED
BY THE BOUNDARIES TO OBTAIN
AN IMAGE OF THE COMPONENT IN
THE DEFAULT ANGLE — 86

OBTAIN "CROPPED" IMAGE OF
THE PART (i.e. NO BACKGROUND) — 88

END

FIG. 3A

APPROVED	O.G. FIG.	
BY	CLASS	SUBCLASS
DRAFTSMAN		

BEGIN

STRUCTURAL AND IMAGE MODELS
ARE IMPORTED AND APPLIED TO CROPPED,
PASTE, PLACED AND BARE EXAMPLE ROIS — 90

REPLACE THE DEFAULT QUALITATIVE AND
QUANTITATIVE PROPERTIES OF THE STRUCTURAL
MODEL WITH VALUES LEARNED BY APPLYING THE
STRUCTURAL MODEL TO THE FOUR IMAGES
(CROPPED, PASTE, PLACED AND BARE) — 92

REPLACE THE DEFAULT ATTRIBUTES OF THE
IMAGE MODEL WITH VALUES LEARNED
BY APPLYING THE IMAGE MODEL TO THE FOUR
IMAGES (CROPPED, PASTE, PLACED AND BARE) — 94

REPLACE THE DEFAULT GEOMETRIC PROPERTIES OF
THE GEOMETRY MODEL WITH VALUES LEARNED
BY APPLYING THE GEOMETRY MODEL TO THE FOUR
IMAGES (CROPPED, PASTE, PLACED AND BARE) — 95

END

FIG. 3B

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BEGIN

IMPORT BOARD TYPES (BARE, PASTE, MULTIPLE PASTE) PART PLAN ～96

BUILD DEFAULT MODELS FOR EACH PART TYPE ～98

FOR A PARTICULAR TYPE OF PART, FOR EACH REFERENCE DESIGNATOR ASSOCIATED WITH THAT PART TYPE PERFORM THE FOLLOWING STEPS: ～100

USE THE DEFAULT IMAGE AND STRUCTURAL MODELS TO DETERMINE WHETHER THE PART IS ON THE BOARD ～102

FOR ONE REFERENCE DESIGNATOR TRAIN THE IMAGE AND STRUCTURAL MODELS ON THE IMAGES ON THE BARE, PASTE AND PLACE BOARDS IMAGES ASSOCIATED WITH THAT DESIGNATOR ～104

USING THE TRAINED MODELS, INSPECT OTHER REFERENCE DESIGNATORS ASSOCIATED WITH THE PART ON THE BARE, PASTE AND PLACE BOARDS ～106

TO 108
FIG. 4B

FIG. 4A

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FROM 106
FIG. 4A

DETERMINE HOW WELL THE TRAINED MODELS CAN DISCRIMINATE BETWEEN TRUE POSITIVES (PART IS PRESENT) AND TRUE NEGATIVES (PART IS ABSENT) ~ 108

OVER ALL REFERENCE DESIGNATORS, CHOOSE THE ONE SET THAT GIVES THE MODELS THE BEST DISCRIMINATION ABILITY ~ 110

IF NO ONE SET OF IMAGES/TRAINED MODELS GIVES GOOD DISCRIMINATION ABILITY USE A CLUSTERING ALGORITHM ON THE MODEL OUTPUT SCORES OVER TRAINED MODELS ON ALL REFERENCE DESIGNATORS TO DETERMINE HOW MANY EXAMPLES ARE NEEDED ~ 112

CHOOSE THE "N" SETS OF REFERENCE DESIGNATOR EXAMPLES WHERE N IS THE NUMBER CALCULATED BY THE CLUSTERING ALGORITHM ~ 114

CREATE, TRAIN AND SAVE IMAGE AND STRUCTURAL MODELS FOR EACH "CANONICAL" REFERENCE DESIGNATOR SET EXAMPLE FOUND IN THE STEP OF CHOOSING THE BEST N REFERENCE DESIGNATOR EXAMPLES ~ 116

END

FIG. 4B

```
          ( BEGIN )
              |
              v
+-----------------------------+
|   OBTAIN AN IMAGE BELIEVED   |----- 118
|     TO CONTAIN A PART        |
+-----------------------------+
              |
              v
+-----------------------------+
|   OBTAIN THE MODELS THAT     |----- 120
| CORRESPOND TO THAT PART TYPE |
+-----------------------------+
              |
              v
+----------------------------------------------+
| APPLY THE IMAGE MODEL TO THE IMAGE AT ALL    |----- 122
| LOCATIONS AND TAKING INTO ACCOUNT ALL ROTATIONS |
+----------------------------------------------+
              |
              v
```

124

DOES IMAGE MODEL INDICATE PART IS PRESENT ?

NO

128

USE STRUCTURAL MODEL TO PERFORM A FULL SEARCH OF THE REGION OF INTEREST (SAMPLE THE RANGE OF POSSIBLE ROTATIONS AND TRANSLATIONS)

YES

126

STRUCTURAL MODEL SEARCHES AROUND SMALL AREA WHERE IMAGE MODEL FOUND PART (CAN ALSO SEARCH FOR ROTATIONS)

130

DOES STRUCTURAL MODEL INDICATE THAT PART PRESENT ?

NO

YES

132

USE GEOMETRY MODEL TO LOCATE PART PRECISELY AND TO PROVIDE ROTATION INFORMATION

(END)

FIG. 5

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```
                    ( BEGIN )
                        │
                        ▼
    ┌───────────────────────────────────────┐
    │ FOR A PART TYPE, LOAD IN THE MODELS    │────  134
    │      STORED IN THE PART  PLAN          │
    └───────────────────────────────────────┘
                        │
                        ▼
    ┌───────────────────────────────────────┐
    │ FOR A REFERENCE DESIGNATOR THAT IS     │
    │ ASSOCIATED WITH THAT PART TYPE, GET A  │
    │ CROPPED IMAGE (ROI) OF THE PART        │────  136
    │        AND ITS SURROUND AT THAT        │
    │        LOCATION ON THE BOARD           │
    └───────────────────────────────────────┘
                        │
                        ▼
    ┌───────────────────────────────────────┐
    │ CHECK TO SEE IF THE PART IS ABSENT BY  │
    │ LOOKING FOR FEATURES THAT PRESENT AT   │
    │      THAT REFERENCE DESIGNATOR ON THE  │────  138
    │ BARE AND PASTE BOARD EXAMPLE BOARDS    │
    │     AND ABSENT ON THE PLACED BOARDS    │
    └───────────────────────────────────────┘
                        │
                        ▼
                   ◇ ARE           ────  140
                     THE
                  "OCCLUSION"              YES    ┌──────────────────┐
                   FEATURES          ───────────▶ │ STOP AND DECLARE │
                   PRESENT                        │   PART ABSENT    │
                     ?                            └──────────────────┘
                        │ NO
                        ▼
    ┌───────────────────────────────────────┐
    │ COMPUTE THE ANGULAR FEATURES           │
    │ IN THE ROI. DETERMINE THE MOST         │────  142
    │ COMMON NON-ZERO ANGLE (THETA)          │
    └───────────────────────────────────────┘
                        │
                        ▼
    ┌───────────────────────────────────────┐
    │ APPLY THE IMAGE MODEL AT THE PART'S    │
    │ EXPECTED ANGLE AND THETA.              │
    │ COMPUTE A PROBABILITY THAT THE         │────  144
    │ PART IS PRESENT AND RETURN             │
    │ THE MOST LIKELY LOCATION               │
    │ <x1,y1> AND ANGLE THETA2               │
    └───────────────────────────────────────┘
                        │
                        ▼
```

TO 146
FIG. 6B

FIG. 6A

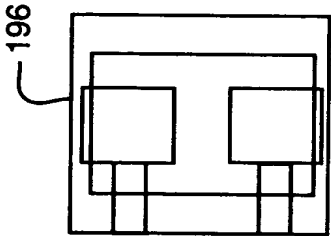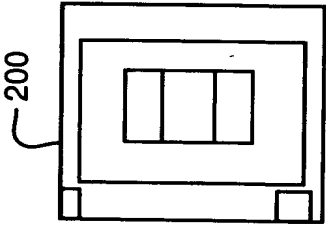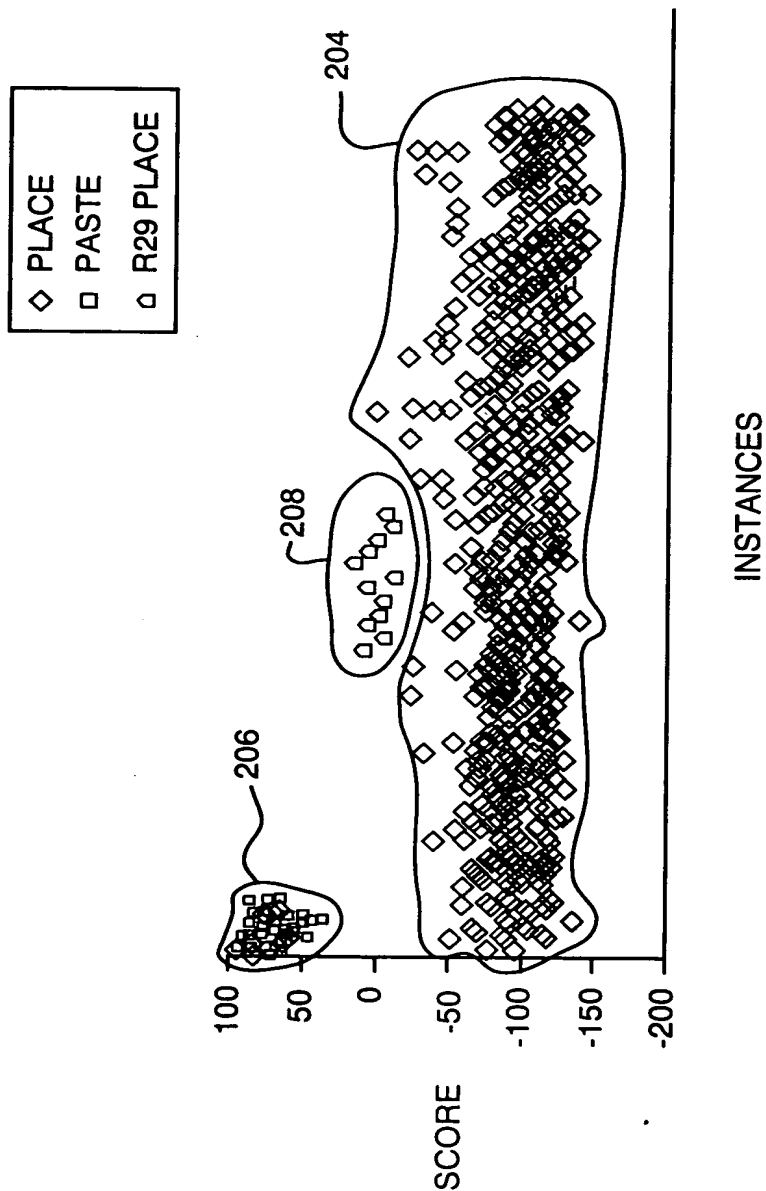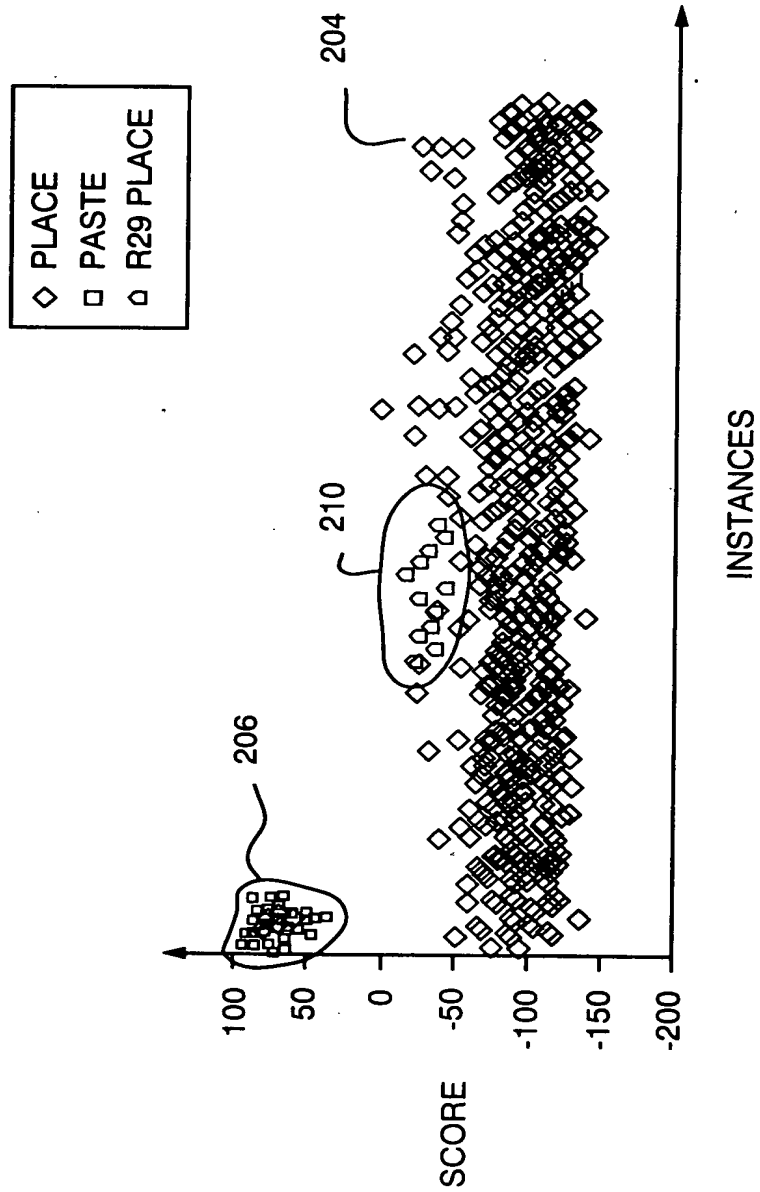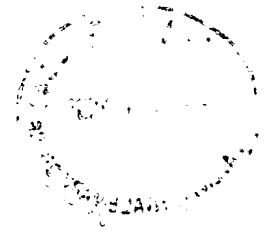| APPROVED | O.G. FIG. | |
| BY | CLASS | SUBCLASS |
| DRAFTSMAN | | |

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FROM 144
FIG. 6A

146

IS
THE PROBABILITY
GREATER THAN THE
FIRST
THRESHOLD
?

YES   NO

148

USE THE STRUCTURAL MODEL
TO VERIFY THAT THE PART
IS PRESENT BY SEARCHING IN A
SMALL AREA AROUND <x1,y1>
ASSUMING THE PART IS ORIENTED
AT THETA2.

150

APPLY THE STRUCTURAL
MODEL TO THE WHOLE ROI
AT THE EXPECTED ANGLE
AND ALSO AT THETA

THE STRUCTURAL MODEL COMPUTES
THE PROBABILITY THAT THE PART
IS PRESENT AND THE BEST LOCATION
<x2,y2> AND ANGLE THETA3

152

154

IS
THE PROBABILITY
GREATER THAN THE
SECOND
THRESHOLD
?

YES   NO

156

THE GEOMETRY MODEL
USES THE POSITION
AND ANGLE ESTIMATE <x2,y2>
AND THETA3 TO EXACTLY
LOCALIZE THE PART.

STOP AND DECLARE
PART ABSENT

STOP AND DECLARE
PART PRESENT AT
<x3,y3> AND THETA4

158

FIG. 6B

APPROVED BY DRAFTSMAN

O.G. FIG.

CLASS | SUBCLASS

166

170

000

168

164

164b

164a

164c

162f

162c

162d

162a

162e

162

162b

162g

160

1002

FIG. 7A

170'

1001

168'

166'

164'

162'

1002

160'

FIG. 7B

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166

168

000

164

162

1002

1002

1002

FIG. 8

FIG. 9B

170

172

1000

1000

1000

FIG. 9A

162f

162c

162d

162a

162e

162b

162f

162g

160

1002

164

FIG. 9D

186

188

FIG. 9C

180

182

184

5002

5002

5002

X

Y

FIG. 10A

198

FIG. 10C

202

FIG. 10E

196

FIG. 10B

200

FIG. 10D

APPROVED	O.G. FIG.	
BY	CLASS	SUBCLASS
DRAFTSMAN		

FIG. 11A

Legend:
◇ PLACE
□ PASTE
◻ R29 PLACE

204
210
206

SCORE
100
50
0
-50
-100
-150
-200

INSTANCES

FIG. 11B

APPROVED | O.G. FIG.
BY | CLASS | SUBCLASS
DRAFTSMAN

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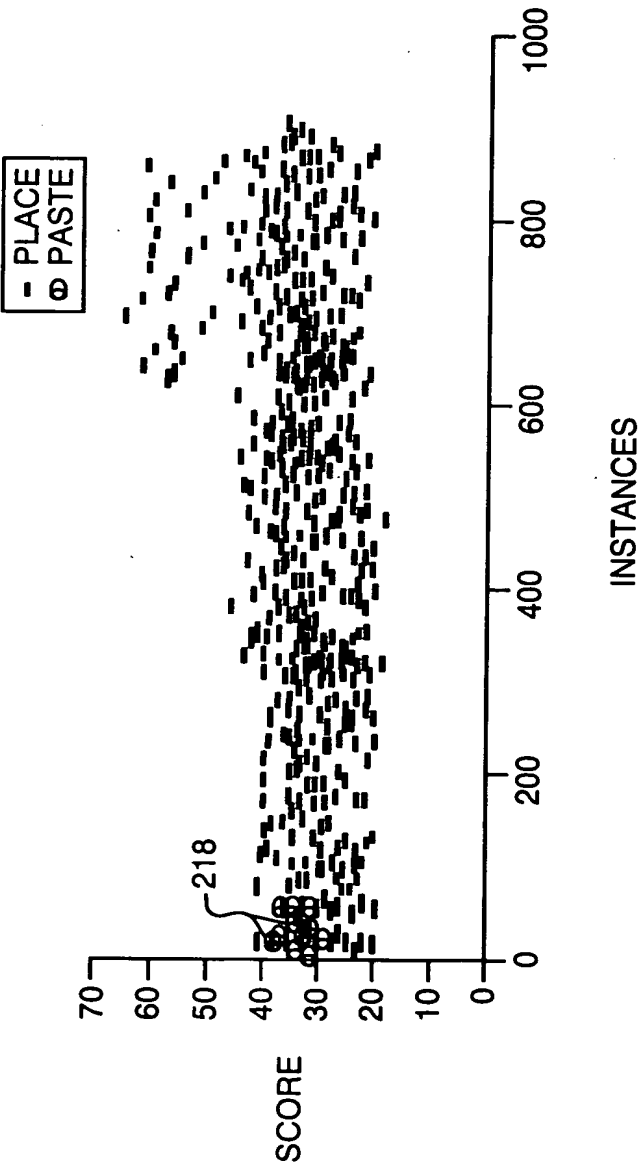09/605,289
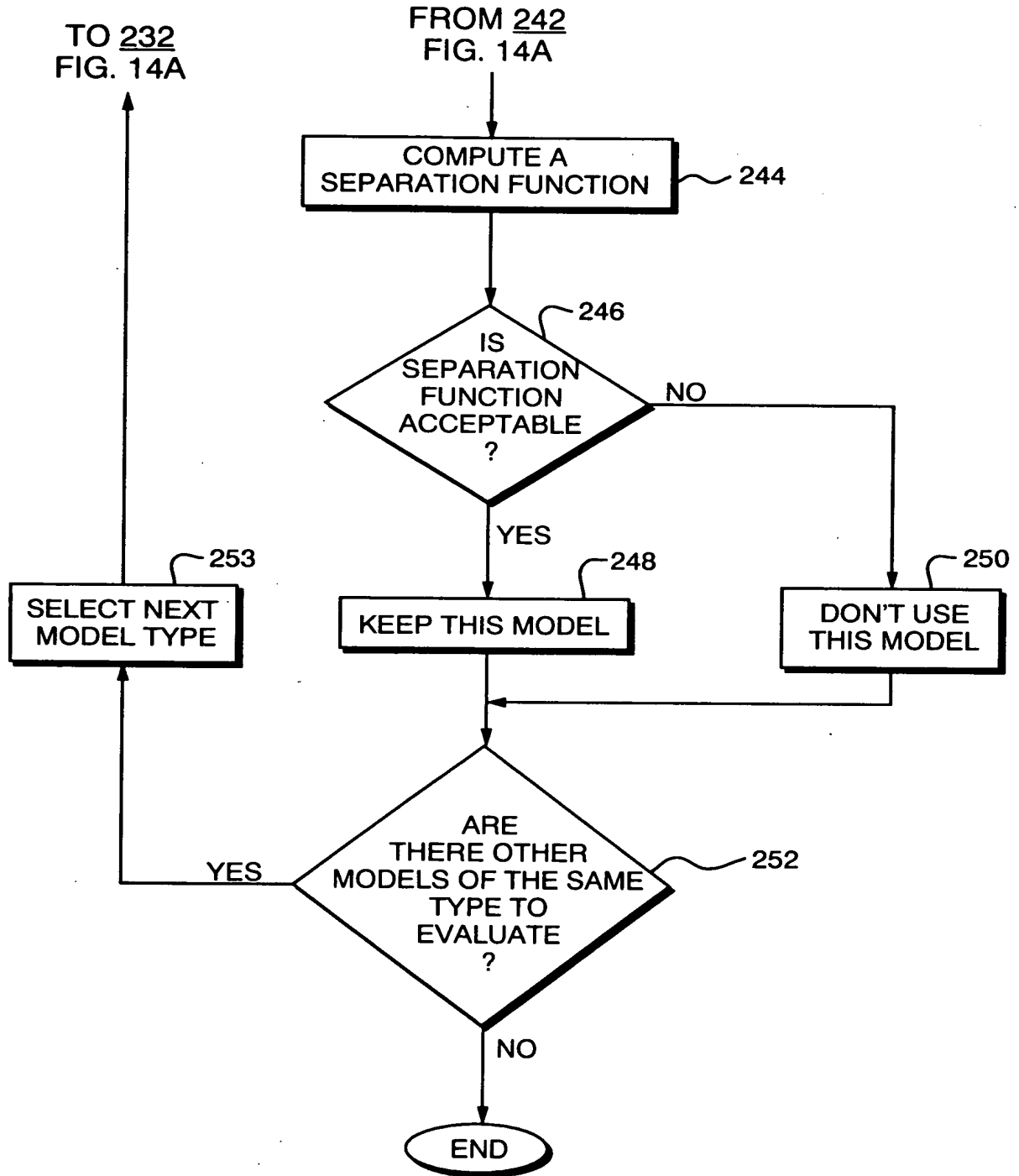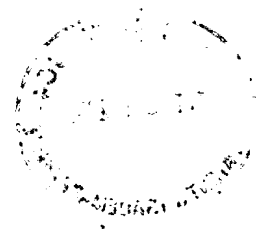
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FIG. 12

FIG. 13

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BEGIN

SELECT A MODEL FOR A PART TYPE — 230

APPLY MODEL TO ALL PLACED
IMAGES OF THE SAME PART TYPE — 232

COMPUTE SCORE BETWEEN MODEL
AND EACH ROI PLACED IMAGE — 234

APPLY MODEL TO ALL PASTE IMAGES
OF THE SAME PART TYPE — 236

COMPUTE SCORE BETWEEN MODEL AND
EACH ROI PASTE IMAGE — 238

SAVE SCORES — 240

CHECK FOR OUTLIERS
(SEE FIG. 14B) — 242

TO 244
FIG. 14B

FROM 253
FIG. 14B

FIG. 14A

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TO **232**
FIG. 14A

FROM **242**
FIG. 14A

COMPUTE A
SEPARATION FUNCTION ⟋ 244

IS
SEPARATION
FUNCTION
ACCEPTABLE
? ⟋ 246

NO

YES

SELECT NEXT
MODEL TYPE ⟋ 253

KEEP THIS MODEL ⟋ 248

DON'T USE
THIS MODEL ⟋ 250

ARE
THERE OTHER
MODELS OF THE SAME
TYPE TO
EVALUATE
? ⟋ 252

YES

NO

END

FIG. 14B

NO. OF
OCCURRENCES

Lplace.place   Lplace.paste

254

258 ⊗   256

                                ⊗ 260

FIG. 14C